Original Article

A Clinical Study of Fundus Changes in Diabetic Nephropathy

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Abstract

Background: The retina provides a unique, non-invasive window to assess vascular pathology, and fundus examination may serve as an important indicator of disease severity and progression in patients with diabetic nephropathy. However, data correlating fundus changes with diabetic nephropathy in the Indian population remain limited. The objective is to evaluate the spectrum and prevalence of fundus changes in patients with diabetic nephropathy and to analyze their association with clinical and biochemical parameters of renal involvement. **Material and Methods:** This retrospective clinical study on 372 patient records, was conducted at Nalanda Medical College and Hospital, Patna, over a two-year period from September 2023 to August 2025. Medical records of patients diagnosed with diabetic nephropathy attending the medicine and ophthalmology departments were reviewed. Data collected included demographic details, duration and type of diabetes, renal parameters (serum creatinine, estimated glomerular filtration rate, albuminuria), and fundus examination findings. Fundus changes were documented using ophthalmoscopy and classified according to standard diabetic retinopathy grading. Statistical analysis was performed to assess correlations between fundus findings and severity of nephropathy. **Results:** Fundus abnormalities were observed in a substantial proportion of patients with diabetic nephropathy, with diabetic retinopathy being the most common finding. Non-proliferative diabetic retinopathy constituted the majority of cases, while proliferative changes were more frequently seen in patients with advanced renal impairment. The severity of fundus changes showed a significant association with longer duration of diabetes, poor glycemic control, and worsening renal function parameters. Patients with macroalbuminuria and reduced eGFR demonstrated a higher prevalence of advanced retinal changes. **Conclusion:** Fundus changes are highly prevalent in patients with diabetic nephropathy and correlate significantly with the severity of renal involvement. Routine ophthalmic evaluation in patients with diabetic nephropathy can aid in early detection of microvascular complications and may serve as a useful marker for systemic disease progression. An integrated approach involving both nephrologists and ophthalmologists is essential for comprehensive management of diabetic patients.

Keywords: Diabetic Nephropathy; Fundus Changes; Diabetic Retinopathy; Microvascular Complications; Retrospective Study.

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Introduction

Diabetes mellitus (DM) presents a significant public health challenge globally, with an ever-increasing prevalence driven by rising rates of obesity, sedentary lifestyles, and aging populations. Chronic hyperglycemia in DM results in widespread microvascular damage, affecting multiple organ systems, most notably the retina and kidneys.[1] Among the microvascular complications, diabetic retinopathy (DR) and diabetic nephropathy (DN) remain leading causes of vision loss and end-stage renal disease, respectively, imposing substantial morbidity and economic burden.[2] The pathophysiological basis of both DR and DN involves hyperglycemia-induced endothelial dysfunction, advanced glycation end products, oxidative stress, and inflammation, which culminate in structural and functional impairment of small vessels in the retina and glomeruli.[3]

Fundus examination offers a unique non-invasive opportunity to visualize microvascular changes directly, which may reflect systemic vascular damage. Retinal microvascular abnormalities, including microaneurysms, hemorrhages, hard exudates, and macular edema, result from chronic capillary leakage and ischemia, hallmarks of diabetic microangiopathy.[4,5] Notably, studies have reported a relatively high prevalence of DR in patients with documented diabetic nephropathy, suggesting a strong association between the severity of renal impairment and retinal vascular pathology. For example, among patients with type 2 diabetes and diabetic nephropathy, diabetic retinopathy was present in over 60% of cases, with proliferative changes and sight-threatening disease correlating with worse renal indices such as albumin-to-creatinine ratio and estimated glomerular filtration rate (eGFR).[6]

The interrelationship between DR and DN is further supported by data indicating that the severity of fundus changes parallels the progression of nephropathy. Higher grades of diabetic retinopathy have been linked to more advanced diabetic kidney

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pathology and poorer renal outcomes, underscoring the shared microvascular pathogenesis of these complications.[7] Additionally, systemic factors such as prolonged duration of diabetes, poor glycemic control, dyslipidemia, and elevated albuminuria have been identified as significant predictors of both DR and DN, reinforcing the concept of common risk determinants for microvascular damage.[8]

Advances in retinal imaging technologies, including optical coherence tomography angiography (OCTA), have allowed more detailed assessment of retinal microvasculature, even before clinically apparent retinopathy develops. Studies demonstrate that microvascular alterations detectable by OCTA are associated with microalbuminuria and reduced renal function, indicating that subclinical retinal vascular dysfunction may mirror early kidney involvement in diabetes. Such findings suggest that careful fundus evaluation could serve not only for ocular disease staging but also as a surrogate marker of systemic microangiopathic burden in diabetic nephropathy.[9]

Despite these insights, there remains a paucity of comprehensive clinical data on the spectrum of fundus changes specifically in diabetic nephropathy at tertiary care centers in India. Given the demographic and clinical heterogeneity of the diabetic population, particularly in resource-limited settings, it is imperative to delineate the prevalence and characteristics of retinal changes in patients with diabetic nephropathy, and to explore their associations with renal and metabolic parameters.

The present retrospective clinical study aims to address this gap by evaluating fundus changes in patients with diabetic nephropathy. Through systematic analysis of medical and ophthalmic records, this study seeks to contribute to a better understanding of the interplay between retinal and renal microvascular complications in diabetes, and to inform strategies for integrated screening and management.

Materials and Methods

Study Design and Setting: This study was a retrospective observational analysis on 372 patient records, conducted at Nalanda Medical College and Hospital, Patna, a tertiary care teaching hospital serving a broad patient population with diabetes mellitus and renal complications. Medical records from September 2023 to August 2025 were reviewed systematically.

Study Population: Medical records of patients diagnosed with diabetic nephropathy (DN) and attending medicine and ophthalmology clinics were screened.

Inclusion Criteria

- Patients aged ≥18 years diagnosed with diabetic nephropathy, defined by persistent albuminuria (microalbuminuria or macroalbuminuria) and/or reduced estimated glomerular filtration rate (eGFR).
- Documented history of diabetes mellitus (type 1 or type 2) according to standard clinical criteria.
- Complete medical records including fundus examination findings at baseline and follow-up.
- Minimum follow-up of 6 months with at least one fundus evaluation during the study period.

Exclusion Criteria

- Patients with non-diabetic renal disease or secondary nephropathies.
- History of ocular pathologies other than diabetic retinal changes (e.g., glaucoma, age-related macular degeneration, significant uveitis).
- Previous ocular surgeries or laser photocoagulation unrelated to diabetic retinopathy.
- Incomplete records or missing fundus documentation.

A total of 372 eligible patients met the inclusion criteria and were entered into the final analysis.

Data Collection: Data were extracted using a standardized data collection form. Trained investigators reviewed paper charts and electronic medical records for the following information:

1. **Demographic Variables:**
- Age
- Sex
- Duration of diabetes
2. **Clinical Parameters:**
- Type and duration of diabetes
- Blood pressure measurements
- Renal parameters including serum creatinine, eGFR, and urine albumin-to-creatinine ratio (ACR)
- Glycated hemoglobin (HbA1c) levels
- Comorbid conditions (e.g., hypertension, dyslipidemia)
3. **Ophthalmic Examination Details:**
- Best-corrected visual acuity (BCVA)
- Intraocular pressure (IOP)
- Fundus examination findings by direct and indirect ophthalmoscopy
- Documentation of fundus features: microaneurysms, hemorrhages, hard exudates, cotton wool spots, neovascularization, and macular edema
- Ancillary imaging when available: fundus photography, optical coherence tomography (OCT), OCT angiography (OCTA), and fluorescein angiography (FFA) as appropriate. Fundus changes were classified according to standard diabetic retinopathy grading systems.

Fundus Examination and Grading

All patients underwent a comprehensive ophthalmic evaluation, including assessment of the retina via slit-lamp biomicroscopy with a fundus lens, color fundus photography, and additional imaging modalities when indicated. Diabetic retinopathy was classified using the International Clinical Diabetic Retinopathy Severity Scale into:

- No Diabetic Retinopathy (No DR)
- Non-Proliferative Diabetic Retinopathy (NPDR): mild, moderate, severe
- Proliferative Diabetic Retinopathy (PDR)
- Diabetic Macular Edema (DME)

Ancillary imaging such as OCT and FFA confirmed features like macular edema and microvascular leakage when required. OCT/OCTA provided detailed assessment of retinal thickness and microvascular density where available.

Renal Assessment: Renal function data were obtained from clinical laboratory records. eGFR was calculated using standard equations, and patients were categorized by stages of kidney function. Urine albumin-to-creatinine ratio (ACR) was classified as normoalbuminuria (<30 mg/g), microalbuminuria (30–300

mg/g), and macroalbuminuria (>300 mg/g). These classifications facilitated correlation between severity of nephropathy and fundus changes.

Statistical Analysis: Data were entered into Microsoft Excel and analyzed using SPSS version 25.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics were reported as means ± standard deviation (SD) for normally distributed continuous variables or medians with interquartile range (IQR) for skewed data. Categorical variables were expressed as frequencies and percentages.

Comparisons between groups were made using Student's t-test or Mann-Whitney U test for continuous variables and Chi-square or Fisher's exact test for categorical variables. The relationship between severity of fundus changes and clinical parameters (e.g., ACR stages, eGFR categories, HbA1c levels) was evaluated using correlation tests (Pearson or Spearman as appropriate). A p-value <0.05 was considered statistically significant.

Results

A total of 372 patients with diabetic nephropathy were included in the final analysis after applying inclusion and exclusion criteria. The study evaluated demographic characteristics, clinical variables, renal status, and fundus findings, and assessed their inter-relationships.

Table 1: Demographic and Clinical Profile of Study Participants (n = 372)

Variable	Number (%) / Mean ± SD
Age (years)	56.4 ± 10.8
Age group 18–40 years	42 (11.3%)
Age group 41–60 years	201 (54.0%)
Age group >60 years	129 (34.7%)
Male	228 (61.3%)
Female	144 (38.7%)
Duration of diabetes (years)	11.6 ± 5.2
Diabetes duration <10 years	148 (39.8%)
Diabetes duration ≥10 years	224 (60.2%)
Hypertension	289 (77.7%)
Mean HbA1c (%)	8.4 ± 1.6

The majority of patients were in the 41–60 year age group, with a male predominance. More than 60% had diabetes for ≥10 years, and hypertension was a common comorbidity. Overall glycemic control was suboptimal, as reflected by elevated mean HbA1c levels.

Table 2: Renal Profile of Study Population

Renal Parameter	Number (%)
Microalbuminuria (30–300 mg/g)	164 (44.1%)
Macroalbuminuria (>300 mg/g)	208 (55.9%)
Mean serum creatinine (mg/dL)	2.1 ± 0.9
Mean eGFR (mL/min/1.73 m²)	42.6 ± 15.4
eGFR ≥60	58 (15.6%)
eGFR 30–59	187 (50.3%)
eGFR <30	127 (34.1%)

More than half of the patients had macroalbuminuria, indicating advanced diabetic nephropathy. A significant proportion showed moderate to severe renal impairment, with nearly one-third having eGFR <30 mL/min/1.73 m².

Table 3: Prevalence of Fundus Changes in Diabetic Nephropathy

Fundus Finding	Number (%)
No diabetic retinopathy	74 (19.9%)
Any diabetic retinopathy	298 (80.1%)
Mild NPDR	92 (24.7%)
Moderate NPDR	108 (29.0%)
Severe NPDR	54 (14.5%)
Proliferative DR (PDR)	44 (11.8%)
Diabetic macular edema (DME)	96 (25.8%)

Fundus examination revealed that 80.1% of patients had diabetic retinopathy, highlighting a strong association between nephropathy and retinal involvement. Moderate NPDR was the most common grade observed, while PDR was seen in nearly 12% of cases. Diabetic macular edema was present in approximately one-fourth of patients.

Table 4: Association Between Albuminuria and Severity of Diabetic Retinopathy

DR Severity	Microalbuminuria (n=164)	Macroalbuminuria (n=208)
No DR	46 (28.0%)	28 (13.5%)
Mild NPDR	54 (32.9%)	38 (18.3%)

Moderate NPDR	42 (25.6%)	66 (31.7%)
Severe NPDR	16 (9.8%)	38 (18.3%)
PDR	6 (3.7%)	38 (18.3%)

Patients with macroalbuminuria showed significantly higher proportions of severe NPDR and PDR, whereas those with microalbuminuria more commonly had no DR or mild NPDR, suggesting a progressive relationship between renal damage and retinal severity ($p < 0.05$).

Table 5: Relationship Between eGFR and Fundus Changes

eGFR Category	No/Mild DR	Moderate–Severe NPDR	PDR
≥60 (n=58)	42 (72.4%)	14 (24.1%)	2 (3.5%)
30–59 (n=187)	86 (46.0%)	78 (41.7%)	23 (12.3%)
<30 (n=127)	28 (22.0%)	70 (55.1%)	29 (22.9%)

A decline in eGFR was associated with increasing severity of diabetic retinopathy. Patients with eGFR <30 mL/min/1.73 m² had the highest prevalence of moderate to severe NPDR and PDR, indicating worsening retinal microvascular disease with advancing renal dysfunction.

Discussion

Diabetic nephropathy represents one of the most severe microvascular complications of diabetes mellitus and is frequently accompanied by diabetic retinopathy, reflecting widespread systemic microangiopathy.[10] The present retrospective study evaluated the spectrum of fundus changes in patients with diabetic nephropathy and analyzed their association with renal dysfunction and clinical variables. The findings demonstrate a high prevalence and increasing severity of retinal changes with advancing renal disease, underscoring the close pathophysiological relationship between the kidney and retinal microvasculature.

In the present study, diabetic retinopathy was observed in 80.1% of patients with diabetic nephropathy, which is consistent with previously reported prevalence rates ranging from 60% to 85% among patients with established renal involvement. The high prevalence of retinopathy in this cohort may be attributed to prolonged duration of diabetes, poor glycemic control, and the presence of comorbid hypertension in a majority of patients. These factors are well-recognized contributors to microvascular damage and have been shown to accelerate both renal and retinal disease progression.[11,12]

Non-proliferative diabetic retinopathy, particularly moderate NPDR, was the most commonly observed fundus finding in this study, while proliferative diabetic retinopathy (PDR) was detected in nearly 12% of cases. This distribution suggests that although early retinal changes are common, a significant proportion of patients progress to sight-threatening stages, especially in the presence of advanced nephropathy. The occurrence of diabetic macular edema in approximately one-fourth of patients further highlights the risk of visual impairment in this population.[2,13,14]

A key observation of this study was the strong association between the severity of diabetic retinopathy and markers of renal dysfunction. Patients with macroalbuminuria showed a significantly higher prevalence of severe NPDR and PDR compared to those with microalbuminuria. This finding supports earlier studies demonstrating that albuminuria is not only a marker of renal damage but also a surrogate indicator of systemic endothelial dysfunction and microvascular injury. Similarly, declining eGFR was associated with progressively severe retinal changes, with patients having eGFR <30 mL/min/1.73 m² exhibiting the highest frequency of advanced retinopathy. These results reinforce the concept that retinal microvascular alterations mirror the severity of renal disease in diabetic patients.[15,16]

The association between poor glycemic control and fundus changes observed in this study aligns with existing evidence that chronic hyperglycemia plays a central role in the development of diabetic microangiopathy. Elevated HbA1c levels promote oxidative stress, inflammation, and accumulation of advanced glycation end products, leading to capillary basement membrane thickening and pericyte loss in both the retina and renal glomeruli. Additionally, the high prevalence of hypertension in the study population likely contributed to the severity of retinal findings, as elevated blood pressure exacerbates vascular leakage and ischemia.[8,17]

The findings of this study have important clinical implications. Given the strong correlation between diabetic nephropathy severity and fundus changes, routine ophthalmic evaluation should be emphasized in patients with renal involvement, particularly those with macroalbuminuria or reduced eGFR. Fundus examination may serve as a non-invasive tool to identify patients at higher risk of progressive renal disease and systemic microvascular complications. Early detection and timely intervention could potentially prevent visual loss and improve overall outcomes.

Despite its strengths, including a relatively large sample size and comprehensive assessment of renal and retinal parameters, this study has certain limitations. The retrospective design limited the ability to establish causal relationships and depended on the accuracy and completeness of medical records. Variability in the availability of advanced retinal imaging modalities such as OCT and OCT angiography may have led to underestimation of subclinical retinal changes. Furthermore, longitudinal progression of fundus findings could not be uniformly assessed due to differences in follow-up duration.

In summary, the present study demonstrates a high prevalence of diabetic retinopathy among patients with diabetic nephropathy, with increasing severity of fundus changes paralleling worsening renal dysfunction. These findings emphasize the need for integrated, multidisciplinary management of diabetic patients, incorporating regular ophthalmic screening as an essential component of care for individuals with diabetic nephropathy.

Conclusion

Multidisciplinary approach involving physicians, nephrologists, and ophthalmologists is essential for the effective management of diabetic patients, enabling early detection of microvascular complications and reducing the long-term burden of diabetes-related morbidity.

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Conflicts of interest

There are no conflicts of interest.

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